Original Communications.

A METHOD OF DETERMINING AMETROPIA BY PRISMATIC REFRACTION.

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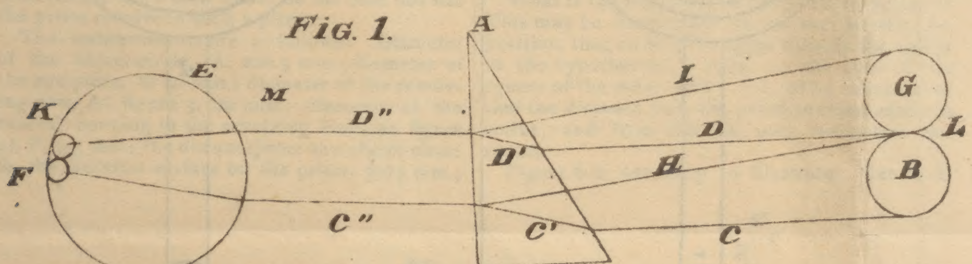
About four years ago this subject first occurred to me and I have, at intervals, been engaged with it up to the present time. I venture to believe I can present the instrument to the profession as an accurate one to decide quickly what glasses are required in hypermetropia, myopia and in astigmatism. It does not concern presbyopia.

The problem is to utilize the refraction of a double prism in determining the glasses required. This we have accomplished with a single prism; but a double one is better, as with the latter the movements of the head of the observer do not so much affect the position of the true and false image. The subject, however, can be illustrated more simply with a single prism.

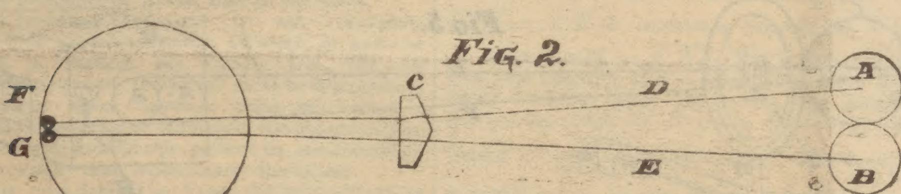
Fig. 1.



Let A, Figure 1, be a prism, B a circular image in front of it, then rays of light, D," C," passing from B to the prism will be refracted in D' C,' and to D" C," and reaching the eye, E, will be brought to a focus upon the retina at F. The image, however, will not be seen at B, but at G, *i.e.*, in the angle of deviation H, I. If we employ two such prisms, their bases applied to each other, such deviation will occur in each prism, and if the circles are of the proper diameter, their inner circumference will appear to touch, as at L, in B, G, and the two images on the retina at F and K will also touch. This is the case in the ametropic eye. If the eye, E, be hyperopic—too short antero-posteriorly—and the circle B of the same diameter using the same prism, then the images B, G will be lapped. If now a convex glass be interposed at M the rays will be brought to a focus at F, K (and this glass will be the measure of the hyperopia), and the retinal and objective, B G, images will touch at their inner margins. If, on the contrary, the eye be myopic—too long antero-posteriorly—images B G will appear separated at L, and consequently at F K. If now a concave glass be interposed at M, the rays will be deflected so as to be brought to a focus at F K, and their edges touch, both within the eye at F K and at the object at L, as in the former case. The glass required to effect this is the measure of the myopia.

Figure 2 will illustrate this with the double prism. Let A B be two circles so large that their edges touch when seen through the double prism C. The rays, D E, after deflection through the prism, will enter the normal eye and be brought to a focus on the retina at F G and the double image of A B will result, the inner edges of which touch. If the prism, C, be made to revolve on its axis and it be accurately centered and the centre of the object circle be centered on a horizontal line with the centre of the prism, and the latter revolves on a plane at right angles to the axis, passing through the object and prism, and also the plane of the object, B, be placed at right angles to said axis, then the prism revolving, the images—circles, true and false—will touch in every meridian at the inner circumference. If, however, these images are separated or lapped at any particular meridian there is astigmatism present in some form; and the glass, either + or — which will cause the images to touch at their inner margins, is the measure of the myopic or hyperopic astigmatism. If all the meridians are alike and the images are

Fig. 2.

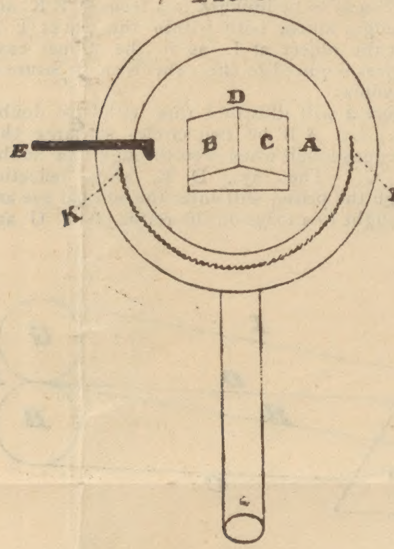


lapped or apart, and the corrective glass be applied, as at M Figure 1, the circles will touch at every meridan as the prism is being revolved, and hence, in such a case, there is no astigmatism but simple general myopia or hyperopia.

By such a plan the proper glasses can be selected in a few moments and the result verified by applying the same in the reading of Snellen's test-types.

The construction of our instrument is as follows: Figure 3 represents the back surface of the eye-

Fig. 3.

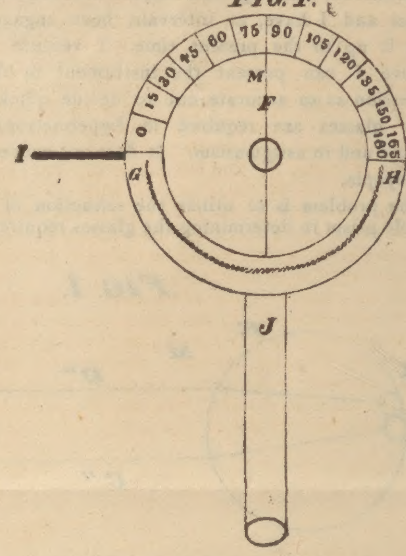


BACK SURFACE OF EYE PIECE.

piece. The disc, A, revolves on its axis. To this is secured by brass clips a double prism, the surfaces of which, B C, are equally inclined, and the ridge of which D cuts the central opening, F, Figure 4, in its vertical diameter. The portion of brass wire, represented at E and I, is an index which denotes the degrees of the scale shown on the front surface of the Eye Disc, Figure 4. As the disc revolves it will be noticed that this index always stands at right angles to the axis or ridge of the prism, shown by the line M Figure 4, and that if the index stood as in Figure 3 it would deflect the rays of light in the horizontal meridian, but not in the vertical. If the index is turned vertically then the prism will refract in that meridian only.

The front view, Figure 4, shows an upper half-circle divided into 180°, reading from left to right. The central opening, F, is in front of the flat surface of the prism and is exactly in the center of the revolving disc, A, Figure 3. Through this the observer looks at the object-circle placed at a proper distance in front of, and from, the eye piece; G H is a spring clip for holding the trial glasses. This eye piece is about

Fig. 4.

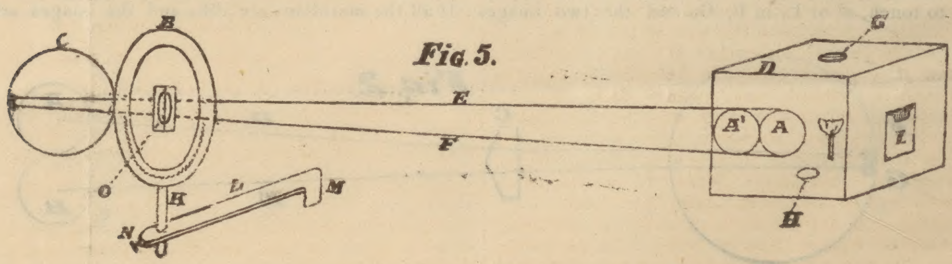


FRONT SURFACE OF EYE PIECE.

four mm. thick; J is an upright of one-fourth inch brass gas tubing, securely attached to the eye piece, and of convenient length. On the back surface of Figure 3 is represented at K L a spring-clip for placing the glasses of the trial-case behind the eye piece.

Figure 5 represents the object-circle, A, cut out of galvanized iron and covered with plain, white, frosted glass. Opposite the centre, and six or eight inches behind A, is a light. This box, D, is closed. The disc, or eye piece, with the prism attached, is seen at B, and the eye of the observer is represented at C, looking through the central opening at the object-circle, A. The

Fig. 5.



rays of light, E F, emanating from the object-circle, pass through the prism and enter the eye of the observer; and by prismatic deflection a false image, A′, of A, the true circle, will be seen on the front surface of the box, D; and if the arrangement is perfect and the eye normal, their inner circumferences will touch, as well as the images at the retina of the eye, as shown at C.

The openings in the box, G H, represent those for air; and the slide door, I, when open, enables one to light the gas jet.

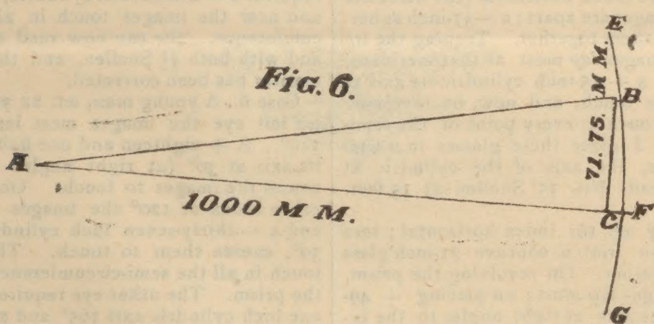
The eye-piece, B, through its upright, K, is secured to a horizontal bar, L, which latter is attached to a convenient object, and may be so arranged that it can be removed from a slot at M, and yet fixed when in place. At N is a thumb-screw to secure the upright of the eye-piece at the exact point necessary to bring the central opening, O, in a right line with the center of the object-circle, A. This right or axial line should be at right angles with the plane of the object-circle, A, and the plane of the eye-piece should be at right angles with the same axis, for then the prism revolving in an undeviating plane will not change the position of the false-image, A′, which would be the case did not the prism revolve in such a plane.

The measurements are as follows: Diameter of the object-circle, A, 220.5 mm.; diameter of the eye-piece, B. 40 mm.; diameter of the revolving disc, A′, figure 3, 22 mm.; diameter of the central opening in the revolving disc (see figure 4), F, 1.5 mm.; the distance from the object-circle to the anterior surface of the prism, 3075 mm.; the central opening exposed to a beam of sunlight, and the two round images of the opening received upon a white, flat surface, the latter placed at right angles to the beam of light, and say 1000 mm. from the anterior surface of the prism. The circumference of these two images is marked off on the white surface, and the distance between the inner edge of one circle and the outer edge of the other measured. This will give the deflecting power of the double prism at 1000, which is 71.75 mm. in our prism. What will be the deflecting power of this prism at 3075 mm. from its front surface to the object-circle? This is found by simple proportion. Thus: 1000 : 71.75 : : 3075 : 220.63125 mm. We construct an object-circle accurately round of 220.5 mm. diameter, in the front surface of the box; and after carefully correcting our own eye, we find that the true and false circles touch at their inner edges. Since now we find the two methods verify each other, the instrument may be assumed to be correct, especially if on revolving the prism, the inner edges of the object-circles touch at every point of the upper semi-circumference.

What is the deflection of this prism in degrees? This may be determined by the well known proposition, that, in a right-angled triangle the square of the hypothenuse is equal to the sum of the square of the other sides. It must be remembered that the distance from the prism to object-circle is cosine, and from this, in part, we obtain the radius.

Figure 6 is necessary to illustrate. Let A C

Fig. 6.



the area of the flat surface of the prism is 10x10 mm., and its greatest thickness at the ridge is about 3½ mm, becoming thinner at the edges so as to refract on each side of the prism about 2° (will be stated accurately directly). The box, D, is about 16 or 18 inches square, and is provided with a reflector behind the light, and is secured permanently to the wall of the office.

A larger object-circle is not desirable, and if a greater distance between it and the prism is wished, say twenty feet, the deflecting power of the prism must be diminished. A longer space between these will secure a greater separation or lapping of the object-circles, which will enable the patient to see this effect more readily than when nearer the object.

It is now desired to know the total refracting power of a given double prism. To determine this the prism is mounted in the eye-piece, and be the cosine, 1000 mm. in this case, or one side of the triangle, A B C, and C B, be the other side, 71.75 mm., deflection of the double prism at 1000 mm. Describe the arc, E B F G? What is the radius of this arc, or A B the hypothenuse. By the proposition we have the formula $\overline{A\,C}^2 + \overline{B\,C}^2 = \overline{A\,B}^2$. Substituting $\overline{1000}^2 + \overline{71.75}^2 = \overline{A\,B}^2 = 1000000 + 514.0625 = \overline{A\,B}^2 = 1005148.0625 = \overline{A\,B}^2$. Extracting square root last quantity A B = 1002.57072 mm. The latter quantity being the radius, the natural sine = the deflection of prism divided by the radius, or $\frac{71.75}{1002.57+} = .071655$. This denotes a double prism having a total deflecting power = 4° 6′ 31.2″, or each side of the prism totally deflects 2° 3′ 15.6″

To render the rays of light still more parallel, I have lately increased the distance of the object-circle from the prism to about twenty feet, or 6045 mm., and diminished the refracting power of the prism, which gives a smaller object-circle.

This double prism refracts at 1000 mm. 25.5 mm. and at 6045 the refraction is 154.1+ mm., which is the diameter of the object-circle, and agrees with the size of the same circle found by experiment with the corrected eye. The total refraction of this prism is $= 0° \; 8' \; 43 \; 8''$.

It may be that it would be useful to still further reduce the size of this circle by diminishing the power of the prism.

A few examples in the practical use of the instrument may be given:

A young man aged 17 years, on looking through the prism, states that the images are apart when the index is horizontal. I know he is myopic, because these are separated in that meridian, and now placing different concave glasses in the clip in front of the eye-piece, it is found that a —37-inch glass causes the images to touch in the left eye. On revolving the prism the images lap, and this is greatest when the index is at 40° corresponding to 130° axis of the prism. On placing a + 30 inch cylindrical glass, its axis is at 130°, the images just touch at that point. I now revolve the prism, leaving both glasses in the clip, and find that the images touch in all the semi-circumference. I place these glasses in a trial frame, the cylindric at an axis of 130°, and he reads No. 15 Snellen at 15 feet.

In the right eye index horizontal (the defective meridian) the images are apart; a —37-inch spherical glass brings them together. Turning the index to 30° the images *lap* most at that meridian, and on placing a + 15-inch cylindric its axis at 120°, the images touch, and now, on revolving the prism, they touch at every point of the semi-circumference. I place these glasses in a trial frame, as above, the axis of the cylindric at 120°, and he reads No. 15 Snellen at 15 feet. $V_2 = \frac{15}{15}$.

Case 2. A boy æt. 16; index horizontal; sees images *apart;* on trial, a concave 21-inch glass brings them together. On revolving the prism, index at 95° images lap most; on placing + 49-inch cylindric its axis at right angles to the index, or 50°, the images touch, and on revolving the prism they touch in all the semi-circumference in the right eye, V R$=\frac{15}{15}$. In the left eye index horizontal, images apart; a —21″ spherical glass brings them together. On revolving the prism, index at 85°, they lap most at that point, and on placing a + 49 inch cylindric, its axis at 175°, they touch at, that degree, and in all the semi-circumference on revolvihg the prism. I place the above glasses in a trial-frame, and he reads No. 15 Snellen at 15 feet. His astigmatism and myopia are therefore corrected, and the meridians at 95° and 85° are less myopic than the meridians of each eye in general.

Case 3. A gentleman, 54 years old, on looking with his right eye, finds the images lapping, index horizontal. By trial a + 37-inch spherical glass causes the images to touch. On revolving the prism they touch in all the semi-circumference. I place + 37″ spherics in the trial-frame, and he reads with each eye Snellen, $\frac{15}{15}$, and with both eyes the same. His hyperopia has been corrected.

Case 4. A lady æt. 20, reads unaided with left eye Snellen 200 at 15 feet, and in right, O, Snellen at 15 feet. On looking she cannot, with right eye, distinguish the outlines of the circles, but only a light blurred appearance. I do not know if she is myopic or hyperopic, but suspect myopia from the form of the eye. I apply a 30″ concave, she sees better, and finally with a $2\frac{1}{2}$ inch glass the images are indistinctly seen to touch, and on revolving the prism, they do so, in all the semi-circumference. In the trial-frame with this glass she reads Snellen $\frac{15'}{50}$.

In the other eye, index horizontal images blurred—weaker concaves improve the vision, finally $-8\frac{1}{4}$ inch spheric causes the separated images to touch. On revolving the prism, index to 75° the images are apart (to the greatest extent) again, and on placing, by trial, a $-9\frac{1}{4}$ inch cylindric, its axis at 165°, they are brought together, and now they touch in all the semi-circumference. On placing this combination in the trial frame she reads Snellen $\frac{15'}{70}$ & $V_2 = \frac{15'}{50}$.

Case 5. A lady, æt. 25 years, on looking through the instrument with her left eye, finds the images most apart the index at 95°, but they touch at the other meridians. A — cylindric of twenty-one inches, its axis placed at right angles to the index, or at 5°, causes the object circles to touch. On revolving the prism the images touch in all the semi-circumference.

The other eye, detected in the same manner, requires a — fifteen inch cylindric, its axis at 175°, and now the images touch in all the semi-circumference. She can now read with either eye and with both $\frac{15}{15}$ Snellen, and the simple astigmatism has been corrected.

Case 6. A young man, æt. 22 years, sees with his left eye the images most lapped, index at 120°. A + eighteen and one-half inch cylindric, its axis at 30° (at right angles to the index), causes the images to touch. On revolving the prism index at 120° the images are most apart and a — thirty-seven inch cylindric, its axis at 30°, causes them to touch. The images now touch in all the semi-circumference on revolving the prism. The other eye requires a + twenty-one inch cylindric axis 165° and a — thirty-seven inch cylindric axis 75°. With either eye and both he reads S. $\frac{15}{15}$, thus his crossed astigmatism has been corrected for each eye.

This instrument, excepting the prism, was made in this place. It need not be expensive and any one familiar with the subject can set it up. Its description may seem intricate, but, when seen, its construction is quite simple.

All that the observer has to answer, in being tested, is do the images touch, or are they apart, or do they lap? If apart, this denotes myopia; if lapped, the patient is hyperopic. Even children can answer these questions satisfactorily. It is commendable then, as the observer can at once comprehend his part in the examination.

It is also a great time-saver, a few moments enabling one to determine the glasses required in the most exact manner.

The name selected for it is PRISOPTOMETER, from *prisma*, prism; *optikos*, optic; and *metron*;

measure; denoting a method of estimating ametropia by the means of a prism.

Finally, we could have demonstrated fully all the optical problems belonging to this subject, but do not consider it necessary as these are found in standard works. We only have desired to present the instrument for consideration in a practical manner.

We have modified this instrument in various ways, but have decided this to be the most practical method of using a prism for measuring ametropia. Thus we tried to use a + six inch glass in combination with the prism to overcome the action of the ciliary muscle and enable the use of a short tube, to render the instrument more convenient, but this was not effectual in controlling that muscle. Again, we endeavored to use a telescope with the prism, but this would not answer, for the patient simply looked at the near image in the telescope when the case demands that the object should be placed at quite a distance from the eye of the observer. Numerous other plans were adopted in the use of the prism, but all failed but this upon which we now rely.

Zanesville, Ohio.

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